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Interim Report

JHRP-92/12

Use of Waste Foundry Sand in Highway Constructio

Sayeed Javed

PURDUE UNIVERSITY

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INTERIM REPORT

USE OF WASTE FOUNDRY SAND IN HIGHWAY CONSTRUCTION

by

Sayeed Javed
Graduate Research Assistant

Joint Highway Research Project

Project No: C-36-50N
File No: 6-19-14

Prepared as Part of an Investigation
conducted by the
Joint Highway Research Project
Engineering Experiment Station
Purdue University

In Cooperation with the
Indiana Cast Metals Association

The contents of this report reflect the views of the author who is responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views of or policies of the Indiana Cast Metals Association. This report does not constitute a standard, specifications, or regulations.

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May 1992

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Interim Report

USE OF WASTE FOUNDRY SAND IN HIGHWAY CONSTRUCTION

To: Vincent Drnevich, Director
Joint Highway Research Project

May 26, 1992
Project No: C-36-50N
File No: 6-19-14

From: C.W. "Bill" Lovell
Professor of Civil Engineering
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The attached report provides information to INDOT in response to the mandate of Senate Bill 209 and House Bill 1056. The report presents a review of available information on the waste foundry sand, their generation process, including molding and casting processes, potential variables, environmental concerns and potential beneficial uses of waste foundry sand. The report also contains the outline of the tests which will evaluate the economical and technical feasibility for benficial uses.

The report is submitted for review, comment and acceptance in fulfillment of the referenced study.

Respectfully submitted

CW Lovell

C. W. Lovell
Research Engineer

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16. Abstract

This study synthesizes the information on the use of waste foundry sand in highway construction. The information was obtained from a review of published literature supplemented by recent unpublished reports and personal correspondence with the experts.

The development of innovative and constructive uses of foundry wastes will provide an opportunity for substantial savings for the foundry industry. This report presents a review of available information on waste foundry sand, their generation process, potential beneficial uses, potential variabilities and environmental concerns associated with the beneficial use. The report also outlines the physical and chemical tests which will be performed in order to assess the environmental acceptability and technical feasibility.

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foundry sand, foundry, molding sand, core sand, highway construction materials, metals, binders, additives, green sand, waste materials, leachate, leaching test	No restrictions. This document is available to the public through the National Technical Information Service, Virginia 22161

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LIST OF ABBREVIATIONS

AFS	American Foundrymen's Society
ASTM	American Society for Testing and Materials
CTL	Construction Technology Laboratories
EPA	Environmental Protection Agency
IAC	Indiana Administrative Code
INCMA	Indiana Cast Metals Association
IDOH	Indiana Department of Highways
INDOT	Indiana Department of Transportation
IDEM	Indiana Department of Environmental Management
LOI	Loss on Ignition
TCLP	Toxicity Characteristic Leaching Procedure
WFS	Waste Foundry Sand

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SECTION 1

INTRODUCTION

1.1 Background

Waste Foundry Sand (WFS) is generated by industries that use sand to form molds and cores for castings. The annual generation of WFS in Indiana is about 200,000 tons. This is a high volume waste and in most cases is non-hazardous. Over the past few years foundries have seen the cost of operations increase and the demands for castings decrease. One area which is being looked at by the foundry manager today is in cutting the cost of waste disposal. Promulgation of RCRA (Resource Conservation and Recovery Act of 1976); HSWA (Hazardous and Solid Waste Amendments of 1984); SARA (Superfund Amendments and Reauthorization Act of 1986); etc., and the scarcity of landfill space have also resulted in costly land disposal facilities. This turn of events has fostered new and innovative approaches to cost control. Constructive applications of foundry wastes may include use in embankments, subgrades, subbases, backfills, vitrification of hazardous wastes, Portland cement kiln feed, Portland cement concrete aggregate, aggregates for bituminous mixtures, rock wool silica and alumina additive, and, snow and ice abrasive.

In view of the benefits to be gained from the utilization of WFS as a construction material, research on this subject is desired. Unfortunately, an extensive review of the literature reveals that the amount of laboratory and field data on the properties and performance of this material for highway purposes is very limited. In order to develop constructive uses of foundry sand, a substantial database on their properties is needed.

The 1991 Indiana General Assembly enacted legislation requiring the Indiana Department of Transportation (INDOT) on its own, or in cooperation with a state supported university to study the feasibility of using WFS in road construction projects undertaken by INDOT. Accordingly, a two year research program on the feasibility of using Indiana WFS in highways has been initiated in the Civil Engineering School at Purdue University in order to evaluate the potential environmental effect and physical/mechanical properties. This research is funded by the Indiana Cast Metals Association (INCMA).

This study presents a four month review of available information on the WFS, their generation process including molding and casting processes, potential variables, environmental concerns and beneficial uses of waste foundry sand. This study is an attempt to provide substantial information to INDOT so that a response to the mandate of Senate Bill 209 and House Bill 1056 may become available.

1.2 Research Objectives

The purpose of this research is to gather and synthesize existing information on waste Indiana foundry sand and to generate new data through experimental research on certain of these materials.

1.3 Research Approach

The tasks necessary to accomplish the stated objectives include:

- review of available information on the use of WFS in highway construction
- conduct a detailed experimental program on physical/mechanical properties
- analysis of data on physical/mechanical properties and evaluation of potential environmental effects
- reporting recommendations for uses of WFS to the INDOT
- writing standards/specifications for use, where possible.

Review of literature indicates that WFS has been used successfully as a fill material in a railroad overpass project located in Wapauca County, Wisconsin [2]. The state of Illinois has also found some applications of WFS as a fine aggregate supplement for portland cement concrete products and asphalt concrete pavements. It has also been used as a silica additive for cement and as a fill material [4]. However no published result containing detailed engineering properties is currently available.

A total of 10 waste foundry samples will be collected for study from 10 different foundries. Initially these samples will be subjected to a series of physical and chemical characteristics tests. The remainder of the experimental program will be devoted to tests on the detailed engineering properties of the waste foundry sand, especially those which would relate to their use in highway fills and pavements.

The characterization tests will consist of:

- complete chemical analysis of each foundry samples
- mineralogical study using x-ray diffraction techniques
- microscopic examination of the shape and texture of particles
- loss on ignition
- grain size distribution, ASTM C 136 & D 422
- Atterberg limits, ASTM D 4318
- specific gravity, ASTM D 854

Selected WFS will then be subjected to engineering properties tests including :

- sulphate soundness, ASTM C 88
- Los Angeles abrasion, ASTM C 131
- maximum and minimum index density, ASTM D 4253 and D 4254
- permeability
- shear strength, ASTM D 3080
- standard compaction, ASTM D 698
- degradation under compaction
- one dimensional compressibility, ASTM D 2435
- California bearing ratio, ASTM D 1883

The chemical/environmental tests will be provided by the sponsoring INCMA. Analysis of data from these chemical/environmental tests and the extent of potential groundwater contamination will be carried out.

These test results will then be compared with those of representative granular materials, to further evaluate the feasibility of WFS for highway uses.

SECTION 2

LITERATURE REVIEW

2.1 Waste Sand Generation

WFS is generated by industries that use sand to form molds and cores for castings. The mold forms the outside of the casting ; the core forms the internal shape. When the part to be made has deep recesses or hollow portions, sand cores must be provided in the mold.

Although there may be differences in certain operations, the basic foundry process varies only slightly from one foundry to another. All foundry operations produce castings by pouring molten metal into molds, often consisting of molding sand and core sand. Once the casting has hardened, it is separated from the molding and core materials in the shakeout process. Castings are cleaned, inspected, and then shipped for delivery. Figure 1 is a schematic of a typical foundry process, showing both finished product and the types of air emissions and wastes generated [12].

In Indiana, the most commonly used process is green sand as will be discussed later. Figure 2 [6] shows a schematic of a typical green sand system.

The wastes common to this sand system can be grouped into two general categories: waste sands and emission control residuals. Waste sands genrally consist of three individual waste types:

1. Waste return sand
2. Mold and core lumps
3. Waste green sand

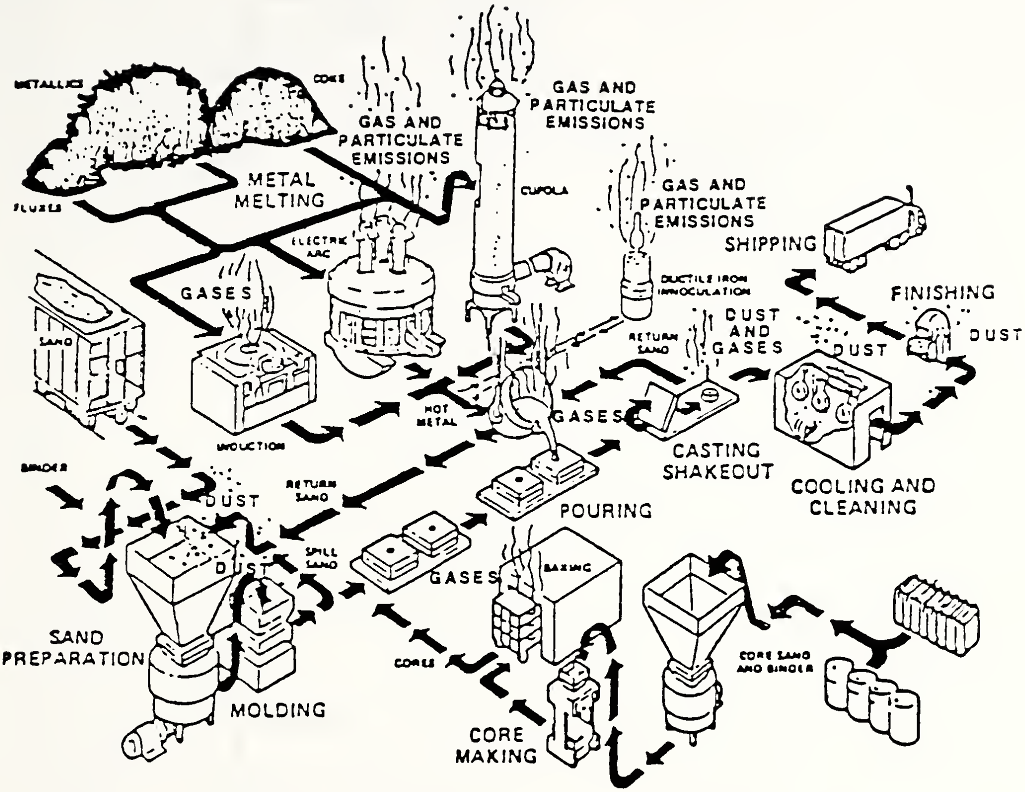


FIGURE 1. Iron and steel foundry process flow and emission sources. (From U.S. EPA, Environmental Assessment of Iron Casting, EPA-600/2-80-021, Washington, D.C., 1980, 17)

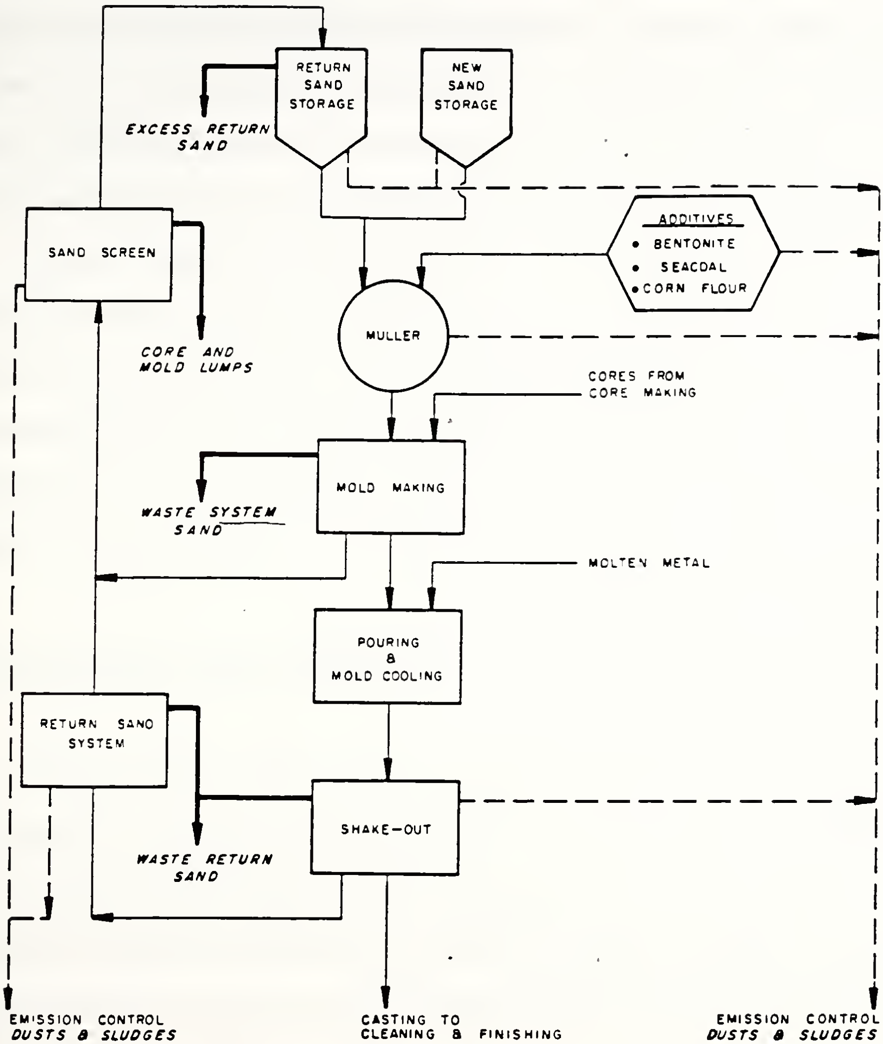


FIGURE 2. Schematic of typical Green Sand molding system (From Kunes T.P., 1983)

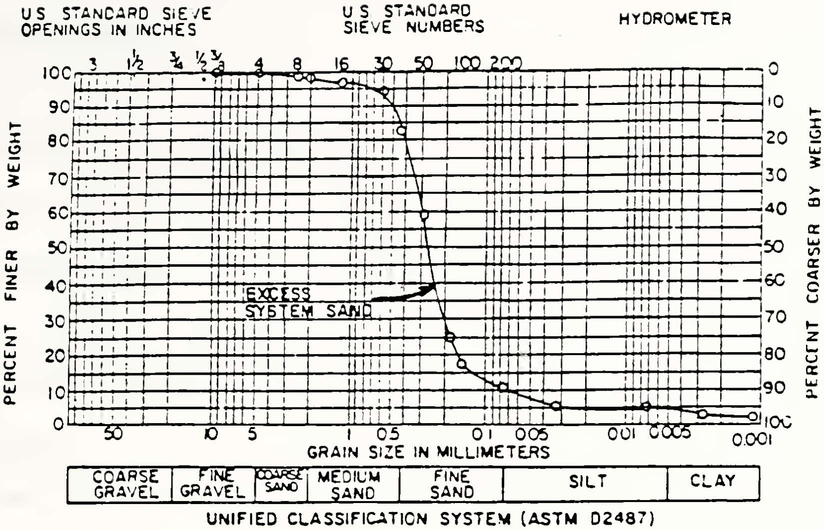
Waste return sand is generated in several areas; at shakeouts; as floor sweeping in finishing areas; and as losses from the sand conveying system. This sand has gone through the pouring process and has been subjected to pouring temperatures. Large amounts of sand are also generated from sand screenings. The mold and core lumps generated can be a significant quantity depending on the amount of core used in the molding process. Waste green or system sand in foundries with high core usage represents the larger quantity of waste sand genrated.

The second category of wastes, emission control residuals, vary greatly in chemical and physical characteistics. The primary emission control residuals from the green sand molding system consists of dusts generated off of mold making, pouring, shakeout, return sand lines and those genrated from sand and bentonite storage and sand mixing processes. In many foundries all theses processes may be handled by the same dust collection system or may be collected by multiple dust collection units.

2.2 Known Physical & Chemical Properties

The WFS is known to be black in color. This blackness is attributed to the combustion of raw sand and to the mixing with the additives like seacoal. Kunes T.P. (1983) has reported that the WFS is typically uniformly graded consisting mostly of fine sand (Figure 3). Also representative samples from the Dalton foundry (Warsaw, IN) and ICC (Indianapolis, IN) tested at Purdue University conformed to this type of grading. However an Auburn foundry (Auburn, IN) sample was found to be silty clayey in nature.

In general, foundry wastes are nonbiodegradable, have little detectable odor, and do not



CURVE	SAMPLE	% GRAV	% SAND	% SILT	% CLAY	SOIL CLASSIFICATION
o	EXCESS SYSTEM SAND	.7	88.3	7.4	3.6	BLACK F-M SAND, TRACE SI, GR, CL

FIGURE 3. Typical Waste System Sand grain size curve (From Kunes T.P., 1983)

support vermin. The leach tests for the WFS used in Overpass Project of Waupaca County, Wisconsin [2] showed that the drinking water standards for iron only were exceeded when using the TCLP test. In Indiana, most of the foundries cast ferrous metals and it is believed that the wastes from the ferrous foundries are non hazardous according to the regulations.

2.3 Potential Variables

A potential problem associated with the beneficial uses of WFS may be its variability. A questionnaire survey has been sent to the different foundries in Indiana (Appendix A) which will indicate the possible extent of variability to be expected in WFS of Indiana. The variables which are considered in this study are :

a) chemical composition of sand

b) binder

c) additives

d) casted/scrap metal

e) core making process

f) molding process

The main variables in the molding and core making processes are the amount and type of binders and/or additives.

a) Chemical composition of sand

The sand to be used in a foundry must have several characteristics [1]. First, it must be cohesive so that the individual grains stick together while the pattern is being removed, otherwise the mold will break apart. Second it must be porous enough so that gases and water vapor can escape when metal is poured into the mold. To a certain degree, the properties of cohesion and porosity work at cross purposes. Adding binder will improve the cohesiveness of the sand grains, but will tend to reduce porosity. Molding sand must also be refractory to withstand the molten metal's high temerature.

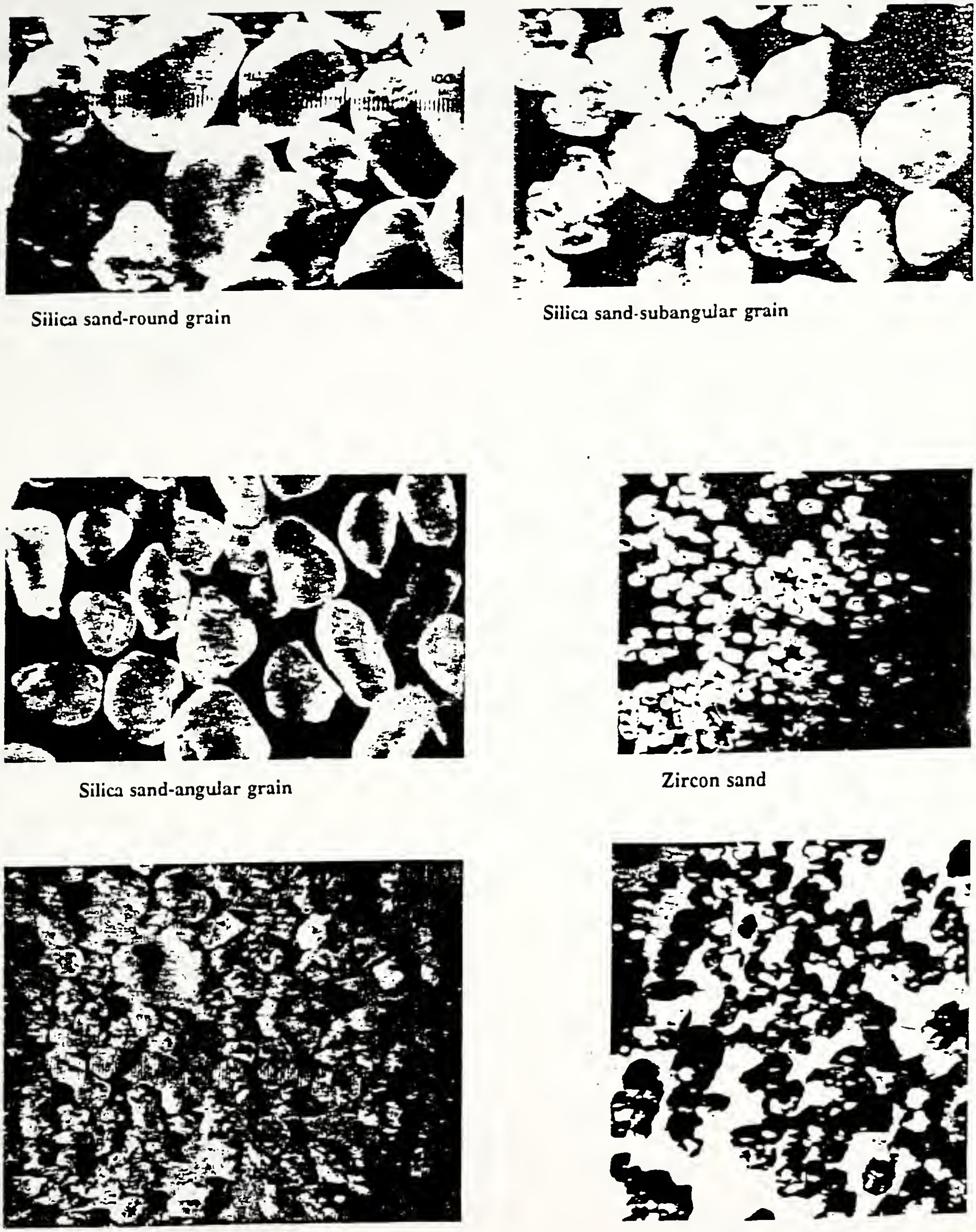
Based on the above criteria the following four chemical compositions of sand are selected for a foundry sand :

1) *Silica* sands are abundantly found in Missouri, Minnesota, Iowa, Illinois and Wisconsin and are economical compared to other sands. Grains of this sand usually have a smooth surface and round shape in sieve sizes through the no. 70, and as the sand becomes finer, they tend to be subangular while retaining a smooth surface (Fig. 4)[9].

2) *Zircon* is produced in Florida and Georgia. The cost of this sand is very high. It is produced in the same grain size as silica sand but its density is twice that of silica [11]. The grains of zircon sands are rounded and elliptical in shape and the surface is very smooth (Fig. 4)[9].

3) *Olivine* also occurs in United States. They are more expensive than silica sands but less expensive than zircon and chromite. Their grains have a very angular shape and a very rough pitted surface character (Fig. 4)[9].

4) *Chromite* is not available in US. Chromite sand grains are angular as shown in Figure 4. The surfaces are relatively smooth and no intra granular porosity is present.



Silica sand-round grain

Silica sand-subangular grain

Silica sand-angular grain

Zircon sand

Olivine sand

Typical Chromite sand

FIGURE 4. Different chemical compositions of sand used in foundry industry (From Mikelonis, P.J.,1982)

b) Binders

Binder is any material which is used to hold sand grains together. Binders which are known to be used in a foundry are :

- bentonite
- resins
- cement
- sodium silicate
- oils

c) Additives

Sand additives are those materials which are added to the bonded sands to improve properties, either during the molding process or during the casting process or both. The primary purpose of additives is to alleviate "burn-on" or fusing of sand to the casting surface. The additives which are typically used are :

- sea coal
- cellulose
- iron oxide
- water

d) Metals

The primary metals which are cast in Indiana are :

- gray iron

- ductile iron
- steel
- aluminum
- copper

In Indiana most of the foundries cast gray iron and steel products (Fig. 5)[8].

e) Core-making Processes

Different core-making processses which are commonly known are:

- sodium silicate process
- cold-setting process
- cold box process
- shell process
- hot box process

Sodium silicate process involves mixing an aqueous sodium silicate solution with the core sand. Cold-setting process uses a mixture of phenolic/furane binders and sand to provide a flowable sand mixture which cures in the cold. These are also reffered to as self-setting process. Cold box process involves the gassing of core sand mixtures to achieve almost instantaneous curing, resulting in high handling strength and precise dimension. Shell process involves resin-coated sand mostly used in automobile foundries. Resin-coated sand results in no segregation of resin from sand and thus enables them to be used in core blowers in the application of automated methods. Preparation of the hot-box sand consists of the mixing of sand, resin and catalyst, without heat and in the normal type of mixer. However, the core is cured at temperatures in the order of 200-300°C.

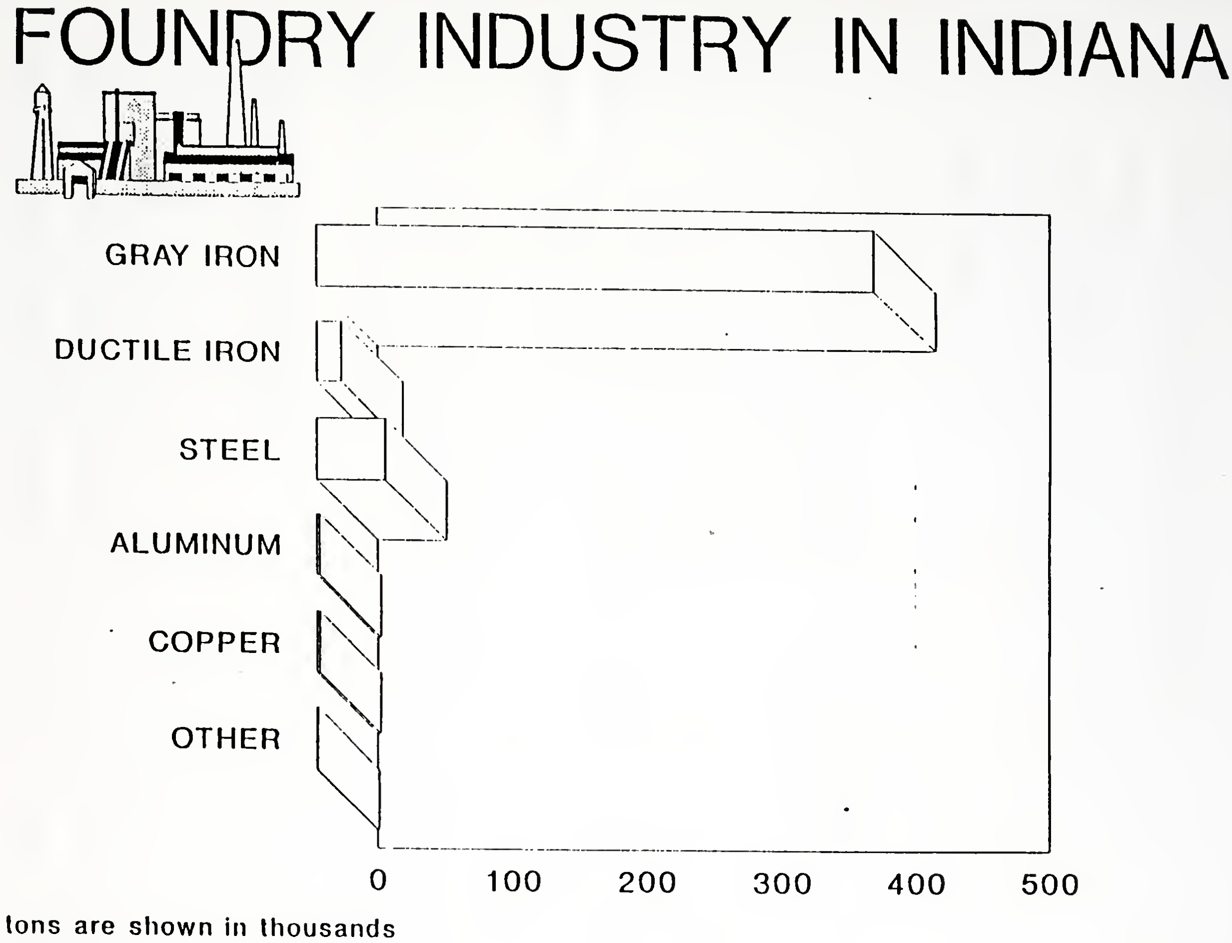


Figure 5. 1990 Iron Production in Indiana (From INCMA, 1991)

e) Molding Processes

Different types of molding processes used in Indiana are :

- green sand
- chemically bonded
- shell mold
- semi-permanent
- investment cast

In Indiana, the most commonly used process is green sand molding (Fig. 6)[8]. Green Sand indicates that the metal is poured into the molds when the sand is damp, as it is when the mold is made [13]. This is the most widely used process for small to medium sized castings in all metals. The advantage of this method is that the process can be of very short time cycle i.e. sand preparation, mold making, closing, pouring and shake-out are ideally suited to a mechanized, continuous process.

It is expected that this study will mainly focus on WFS generated from green sand molding used for gray iron products.

2.3 Potential Beneficial Uses of WFS

Many options may be available for the constructive uses of foundry wastes. However, before concluding that WFS is suitable for constructive use, one should consider: 1) the waste's physical and chemical properties; 2) the regulations which govern its handling, storage and

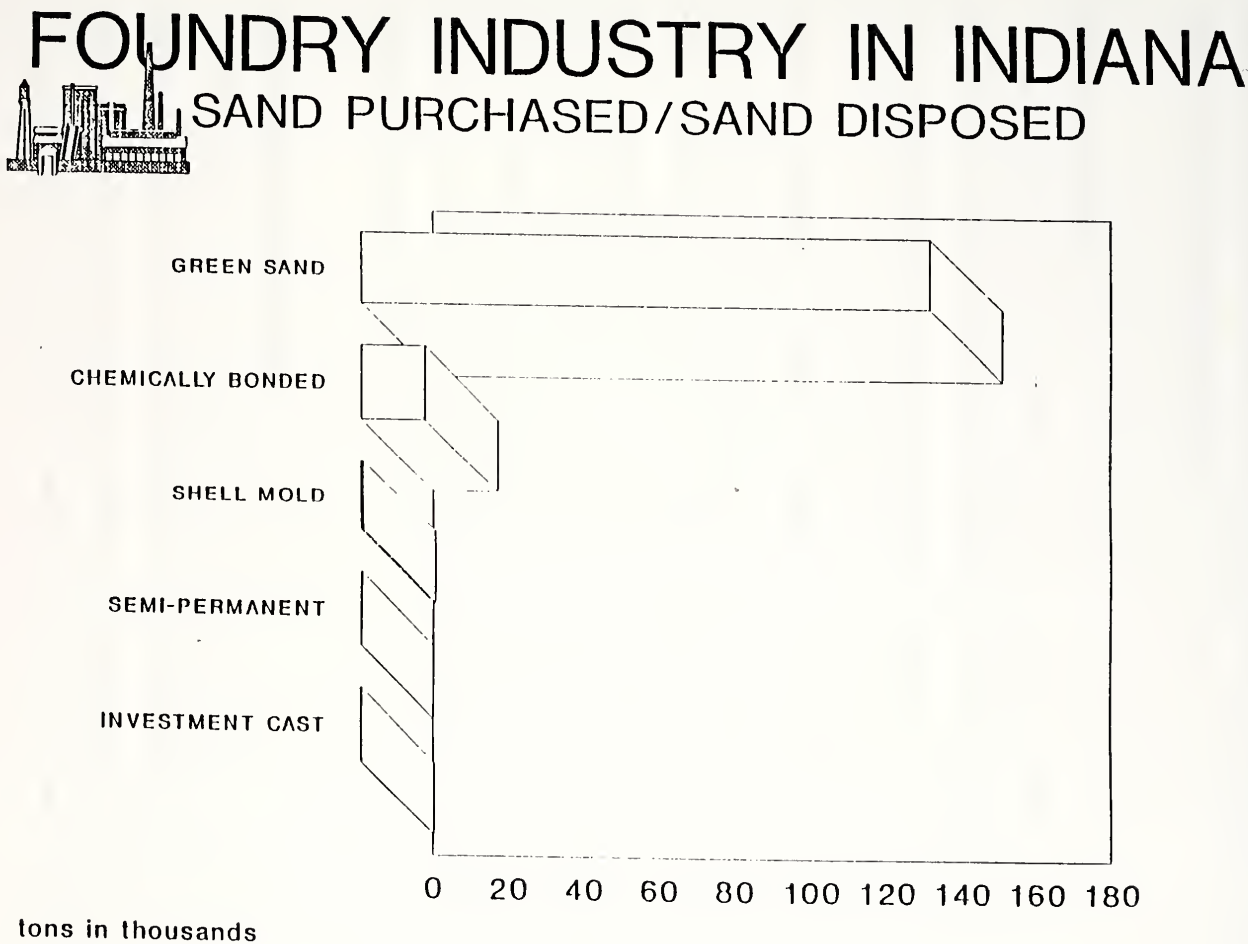


Figure 6. Sand Purchased/ Sand Disposed in Indiana (From INCMA, 1991)

disposal; and 3) various local conditions which may present a market for the material. This research will take into account all three factors.

Portland Cement Kiln Feed

Portland cement is the pulverized form of clinker, the product of the kiln. Clinker is composed of calcium silicates, calcium aluminates and calcium aluminoferrites inter-ground with calcium sulphate (gypsum). Raw materials for manufacture of cement must contain appropriate proportions of calcium oxide, silica, alumina, and iron oxide. Research conducted by Construction Technology Laboratories (CTL), a subsidiary of the Portland Cement Association, Illinois,[4] found that waste sand sample from a gray iron foundry contained approximately 88% silica, 5% alumina, 1% iron oxide and 5% loss on ignition (LOI). Sodium (Na_2O) and potasium (K_2O) levels were found to be in acceptable limits at 0.19% and 0.25% respectively. Based on this chemistry the WFS was found to be an attractive alternate/supplemental raw material for cement kilns. It was also found that WFS contributed a small beneficial effect in strength development over the control mix as strength increased with increasing increments of foundry sand in gypsum to produce cement.

Portland Cement Concrete Aggregate

Portland cement corcrete is composed of portland cement, water and aggregates of various sizes. In Illinois [4], the important parameters for evaluating physical properties of a variety of WFS were evaluated. Those include : particle size distribution, fineness modulus, dust content, density, organic content, deleterious materials content and grain shape. The majority of samples failed the ASTM specifications for particle size distribution (C136), fineness modulus (C33), dust content (C33), density (C330 & 331), and organic content (D2974), but passed the requirements for deleterious materials content and grain shape. Thus it was concluded that a total substitution for the natural fine aggregate is not appropriate. Thus, lower strength applications may exist which may be appropriate for concrete products formed by blending portion of foundry sand with natural fine aggregate, such as: subbases; grouts; side walks; curb ramps and steps; right of way markers and riprap.

Aggregates for Bituminous Mixtures

A project was undertaken in Illinois with the Asphalt Institute to determine the feasibility of supplementing fine aggregate with WFS [4]. The project consisted of two phases. Phase one was designed to evaluate the physical properties of the sand, while in phase two, the physical properties of an asphalt concrete mixture formulated with foundry sand was then compared to those of a control mix. The laboratory tests conducted in phase one were : soundness, sieve analysis, specific gravity, absorption, friable particles, sand equivalent, hydrometer analysis and plasticity index.

Samples of WFS from an iron and a steel foundry were found to almost satisfy the fine aggregate requirements of several state transportation agencies, with the exception of low sand equivalent values for the WFS. Laboratory testing of WFS as a replacement for standard sand in asphalt revealed that it could be used satisfactorily.

Rock Wool Silica and Alumina Additive

Rock wool, or mineral fibres, is a material, like fiberglass, which is used for thermal insulation and to reinforce other materials. However, it is a fiber having higher density and does not have the high purity of fiberglass or other glass products. The fibers are produced combining steel blast furnace slag or basalt with silica and alumina in a cupola furnace and then fiberizing the molten material. High silica content in many foundry sands and high alumina content in investment casting waste shell make them suitable raw material in the manufacture of rock wool mineral fibers.

Hazardous Waste Vitrification

Foundry wastes have been used by some foundries for treating hazardous wastes generated within the foundry. Several hazardous waste treatment process have been permitted which use select foundry wastes to blend with hazardous furnace dusts to render the wastes nonhazardous [4].

Fill Material

A major area for the constructive use of WFS, is as a fill material. These uses include embankments, subgrade under pavements, backfills and daily cover requirements for landfills. For years, foundry wastes have been used as a supplement for daily earth cover over municipal wastes.

One property of particular importance for landfill daily cover is permeability. The purpose of landfill cover is to reduce infiltration of the disposed wastes by rainfall, limit blowing, prevent access by vermin, limit erosion, and present an acceptable appearance. Therefore, typical permeabilities for landfill cover range from 10E-4 to 10E-6 cm/sec [2]. Also, in the case of final cover, gradation is important for re-vegetation. In a study by Stephens and Kunes [2], foundry wastes were shown to be an economic alternative for final cover at a municipal landfill. At the foundry landfill, the permeability of excess system sand was found to be 3.44 * 10E-6 cm/sec and the permeability of mixed sand and sludge was found to be 1.17 * 10E-7 cm/sec. This resulted in a vigorous growth on the site and in considerable savings. Also, in the case of WFS as daily cover at a municipal landfill, considerable saving was found by using a 50-50 mix of excess system sand and imported soil which resulted in a combined permeability of 3 * 10E-6 cm/sec.

The physical properties of concern for highway fill applications are: the relationship between moisture and density, plasticity index, liquid limit, particle size distribution, permeability, shear strength and compressibility. These physical tests will be conducted to evaluate their suitability.

Snow and Ice Abrasives

According to Indiana Department Of Highways IDOH, 1988, Section 903 (f), the abrasives are required to pass the following gradation requirements

Passing the 3/8" sieve.................100%

Passing the # 50 sieve................0-30%

Passing the # 200 sieve.................0-7%

Although most of the WFS have greater than 30% passing No. 50 sieve, some of them have potential for use as a snow and ice abrasives.

2.5 Environmental Concerns

The Office of Solid and Hazardous Waste Management of the Indiana Department of Environmental Management (IDEM) adopted final solid waste management regulations in August 1988 which became effective in February 89. These regulations classify foundry wastes on the basis of results from the EP Toxicity Tests and a modified EP Toxicity water leaching procedure (Indiana Leach Test) as shown in Table 1 (329 IAC 2-9). Wastes which leach parameters in concentration at or below the concentrations shown are classified as waste suitable for disposal in Types I, II, III, or IV sites. Wastes that are documented to pass the Type IV criteria have minimal requirements for disposal and are not subject to the provisions of the regulations (329 IAC 2). The regulations also provide for beneficial use of foundry sand meeting the Type III category, if the use is "legitimate", including the use as a base for road building (329 IAC 2-3-1 (14)). Other uses may be approved if they are determined to be legitimate uses that do not pose a threat to public health or the environment.

For sites Type I, II and III , additional siting restrictions apply. These facilities must also have a soil barrier between the solid waste and any aquifer. The thickness of the soil barrier depends on the waste type and permeability, the physical and chemical properties of the soil, the nature of groundwater resources in the area and the use of alternative liner technology (329 IAC 2-10-4). Facilities accepting waste Types I, II or III require formal detailed permit applications,

TABLE 1 (from 329 IAC 2-9-3)

IDEM FOUNDRY WASTE CLASSIFICATION GUIDELINES CONCENTRATIONS (MG/L)

(1) For Parameters Using the EP Toxicity Test:

Parameter	Concentrations (Milligrams per liter)			
	Type IV	Type III	Type II	Type I
Arsenic	≤ 0.05	≤ 0.50	≤ 1.25	< 5.00
Barium	≤ 1.00	≤ 10.00	≤ 25.00	< 100.00
Cadmium	≤ 0.01	≤ 0.10	≤ 0.25	1.00
Chromium	≤ 0.05	≤ 0.50	≤ 1.25	< 5.0
Lead	≤ 0.05	≤ 0.50	≤ 1.25	< 5.0
Mercury	≤ 0.002	≤ 0.02	≤ 0.05	< 0.20
Selenium	≤ 0.01	≤ 0.10	≤ 0.25	< 1.0
Silver	≤ 0.05	≤ 0.50	≤ 1.25	< 5.0

(2) For Parameters Using the Leaching Method Test:

Barium	≤ 1.00	≤ 10.00	≤ 25.00	*
Boron	≤ 2.00	≤ 20.00	≤ 50.00	*
Chlorides	≤ 250.00	≤ 2.50	≤ 6.25	*
Copper	≤ 0.25	≤ 2.50	≤ 6.25	*
Cyanide, Total	≤ 0.20	≤ 2.00	≤ 5.00	*
Fluoride	≤ 1.40	≤ 14.00	≤ 35.00	*
Iron	≤ 1.50	≤ 15.00	*	*
Manganese	≤ 0.05	≤ 0.50	*	*
Nickel	≤ 0.20	≤ 2.00	≤ 5.00	*
Phenols	≤ 0.30	≤ 3.00	≤ 7.50	*
Sodium	≤ 250.00	≤ 2.50	≤ 6.25	*
Sulfate	≤ 250.00	≤ 2.50	≤ 6.25	*
Sulfide, Total	≤ 1.00**	≤ 5.00	≤ 12.50	*
Total Dissolved Solids	≤ 500.00	≤ 5.00	≤ 12.50	*
Zinc	≤ 2.50	≤ 25	≤ 62.50	*

Parameter	Acceptable Range (Standard Units)			
pH	6-9	5-10	4-11	*

* Testing is not required

** If detection limit problems exist, please consult the office of solid and hazardous waste for guidance.

with Type III being somewhat less restrictive. For example, Type III sites only require additional cover and do not require ground water monitoring.

The results of Toxicity Characteristic Leaching Procedure (TCLP) and Indiana Leach Test will be provided by the sponsoring agency (INCMA), and on the basis of these tests all the potential benficial uses will be finally analysed.

SECTION 3

SUMMARY AND CONCLUSIONS

This report provides information to INDOT in response to the mandate of Senate Bill 209 and House Bill 1056. In this connection the report presents a review of available information on the WFS and their potential beneficial uses together with environmental concerns. Potential variables associated with the beneficial uses are also discussed. The report also contains the outline of the tests which will evaluate the economical and technical feasibility for beneficial uses. The economic implications of beneficial reuse are not discussed in this interim report because no information is available from the foundries of Indiana at this time. However the final study of this research will take into account the various local conditions which may favor a market for the material. Based on the literature review, the following conclusions are drawn:

1. Molding sand and/or cores used in the process of metal casting, result in the generation of large quantities of WFS.

2. The chemical, physical and engineering properties of WFS vary considerably, depending on the differences in the physical and chemical nature of raw sands, binders, additives, casted/scrap metals, core making and molding processes.

3. Research conducted by the the Illinois foundries and the Illinois Department of Commerce and Community Affairs found that WFS is a suitable substitute/additive for Portland cement kiln feed; aggregates for Portland cement and bituminous mixtures; rock wool silica and alumina additive; hazardous waste vitrification; and fill material.

4. Snow and ice abrasives is another potential beneficial use of WFS.

5. The WFS is known to exceed drinking water standards for iron in some cases. Hence there is a potential environmental concern regarding their beneficial uses.

6. The level of variability, contamination and economics, with respect to the specific source of WFS and the location of facility, must be determined to assess its viability prior to its use in highway construction.

7. It is probable that WFS can be used for benficial purposes, based on environmental acceptability, market suitability and technical feasibility.

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Appendix A - Foundry Waste Sand Survey

FOUNDRY WASTE SAND SURVEY

Company Name:____
Company Contact/Title:____________________________________
Mailing Address:____
City:______________________ State:__________ Zip:__________
Phone:______________________ FAX: ____________________

1. What metals and amounts did you cast in 1991?

Iron ____________________
Ductile Iron ________________
Steel ____________________

Aluminum __________________
Copper ____________________
Others ____________________

2. New sand information.

Type	Used As		Location From	GFN	pH	Purchase	
	mold	core				Quantity tons/month	Delivered Cost $/ton
Silica							
Zircon							
Olivine							

3. Molding Process

Green Sand Molding:____
Chemical Method:______
Shell Molding: ________
Investment Cast : _______
Semi Permanent :_______

4. Typical screen distribution (if possible)

Sieve #	Molding	Coremaking	Waste	Sieve #	Molding	Coremaking	Waste
4				100			
10				140			
20				200			
40				270			
60				Pan			

5. Binder Type

Type	Used As Mold	Used As Core	Additive
____________	____	____	___ Seacoal
____________	____	____	___ Cellulose
____________	____	____	___ Iron Oxide
____________	____	____	___ Water
____________	____	____	___ Other ________

6. Do you separate your spent molding sand from other solid wastes, such as core sand, slag, or baghouse dust, prior to disposal ?________

7. Could you perform this separation if it would enable benficial re-use or become otherwise necessary to do so ?__________

8. What percentage of your waste sands are considered hazardous by local standards ?_____%

9. How much waste sand (in tons) do you generate annually _______ What percent from core room ?______% , Molding department _______% , Other ______%

10. How many times do you recycle your sand ? ________ Or, how often and how much sand do you remove from the system ?________

11. If you treat, what did it cost, per ton, to treat your waste sand in order to be able to land dispose of it ? $_______________/ton.

12. What did it cost, per ton, to haul and dispose of your waste sand ? $___________/ton

13. What were the associated labor costs ? $________________/ton

14. What Type(s) of disposal facility did you use for waste sand in 1991?

____ Municipal landfill(s) ____ Foundry's own landfill(s)
____ Privately owned landfill(s) ____ Other (list here)______________________

15. What is the distance to the disposal site(s) ? ________________

16. Has your waste sand been ever re-used for any beneficial purpose?

Type of project ? ____
Other parties involved : ____
Quantity of sand used : ____
Sand Storage location : ____
Dates of project : ____
Company contact for further information : ___________________________

18. What is/are the reason(s) why your waste sands are not currently benficially re-used ?

___ Prohibited by State EPA
___ No apparent market for re-use in my area
___ Not economical - quantities too small for re-use
___ No place to store in order to accumulate quantity
___ Fear of future liability from leaching, etc.
___ State EPA requirements/paperwork too invoved
___ Easier to landfill
___ Free landfill disposal
___ Other (list here) ______________________

Our research includes re-using foundry waste sands in highway construction. If you have any analytical information on your waste streams, please attach any data you would be williing to share with us as part of this project at the following address :

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